

2018-10-08

# Changes in physical activity, weight and wellbeing outcomes among attendees of a weekly mass participation event: a prospective 12-month study.

Stevinson, C

<http://hdl.handle.net/10026.1/12660>

---

10.1093/pubmed/fdy178

Journal of Public Health

Oxford University Press (OUP)

---

*All content in PEARL is protected by copyright law. Author manuscripts are made available in accordance with publisher policies. Please cite only the published version using the details provided on the item record or document. In the absence of an open licence (e.g. Creative Commons), permissions for further reuse of content should be sought from the publisher or author.*

Pre-publication version

Stevinson C, Hickson M. Changes in physical activity, weight and wellbeing outcomes among attendees of a weekly mass participation event: a prospective 12-month study. Journal of Public Health 2018 <https://doi.org/10.1093/pubmed/fdy178>

**Changes in physical activity, weight, and wellbeing outcomes among attendees of a weekly mass participation event: a prospective 12-month study**

Stevinson C<sup>1</sup>, Hickson M<sup>2</sup>

<sup>1</sup>School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, LE11 3TU, United Kingdom. E-mail: C.D.Stevinson@lboro.ac.uk

<sup>2</sup>Institute of Health and Community, Plymouth University, Plymouth, PL4 8AA, United Kingdom. E-mail: mary.hickson@plymouth.ac.uk

## **ABSTRACT**

### **Background**

Mass participation events are recognised as a way of engaging low active individuals in health-enhancing physical activity, but there is a need to investigate the sustained effects on behaviour and health. This study aimed to examine changes in self-reported physical activity, weight, and wellbeing over 12 months in participants of *parkrun*, a weekly mass participation 5km running event.

### **Methods**

New *parkrun* registrants (n = 354) completed self-reported measures of physical activity, weight, happiness, and stress, at registration, 6 months and 12 months. Objective data on attendance and fitness (i.e. run dates and finishing times) were obtained from the *parkrun* database.

### **Results**

Overall physical activity levels were high at baseline, but significantly increased over the first 6 months, before declining. By 12 months, weekly physical activity was 39 minutes higher than baseline. Significant reductions in body mass index were observed over 12 months, with a weight loss of 1.1% in the whole sample, and 2.4% among overweight participants. Modest increases in happiness, and decreases in perceived stress were recorded. Run times suggested a 12% improvement in fitness during the study.

### **Conclusion**

Significant changes in weight, fitness, and wellbeing outcomes indicate the public health benefits of regular participation in *parkrun*.

## INTRODUCTION

Community-based mass participation sporting events are recognised as a potential means of involving low-active individuals in physical activity through a focus on social engagement or fundraising<sup>1</sup>. By emphasising inclusivity over ability, they may provide a bridge towards regular physical activity participation and associated health benefits.

Although the evidence base is limited<sup>2</sup>, some promising findings have been reported. Among participants of a cycling event in Australia, novice riders reported increased cycling frequency in the following month<sup>3</sup>. Similarly, three months after taking part in a running event in the United States, positive attitudes towards regular exercise were reported among the less active and less experienced participants<sup>4</sup>. A study in Ireland surveyed female participants before a 10km run/walk and three months after<sup>5</sup>. Although most participants were moderately to highly active in preparation for the event, over one third reported significant decreases in weekly activity three months later. These studies highlight the potential for mass events to generate motivation for continued activity for some participants, while indicating the challenge in sustaining behaviour longer-term.

Notably existing research has focused on events taking place annually. One example of a mass participation physical activity event that operates on a weekly basis is *parkrun*<sup>6</sup>. Since being initiated in the UK, *parkrun* has developed into a global network of more than 1100 free, weekly, timed 5km runs/walks in public spaces, focusing on community inclusion and providing a supportive environment for physical activity. The regularity of these events may offer an advantage over annual mass participation events in maintaining motivation and physical activity over time.

The health and wellbeing potential of participation in *parkrun* has been widely endorsed<sup>7,8</sup>, and early research is encouraging. A cross-sectional analysis of 7308 adult participants in the UK who had been attending a median of 12 months, indicated that *parkrun* was successful in engaging some population sub-groups who are underrepresented in national physical activity statistics (females, middle-aged and older adults, and overweight)<sup>9</sup>. Over half the sample were not regular runners before starting *parkrun*, and these participants were most likely to attribute health and wellbeing improvements to *parkrun* involvement. To examine whether these perceived benefits were observed when outcomes were monitored prospectively, a 12-month longitudinal study with new registrants of *parkrun* was designed.

## Aim

This study aimed to examine changes in self-reported physical activity, weight, and wellbeing in a cohort of new *parkrun* registrants over 12 months. In addition, the scale of change was explored in sub-groups based on weight category, and initial running status.

## **METHOD**

Institutional ethical approval (R11-P169) was provided to conduct a prospective 12-month observational study of newly registered parkrun participants in the UK with data collected at registration (baseline), 6 months, and 12 months.

### **Participants**

New adult ( $\geq 18$  years) registrants of a UK parkrun event between October 2012 and January 2013 were invited to participate in the study through a link on the parkrun online registration page. After providing informed consent, participants continued to the study baseline questionnaire. A link to subsequent questionnaires was sent by e-mail, with two reminders to non-responders.

### **Outcome measures**

The baseline questionnaire included sections for sociodemographic (sex, age, education level, employment status, ethnic group) and health (general health<sup>10</sup>, disability<sup>10</sup>, height, weight) information, physical activity, and psychological wellbeing (happiness, stress).

Physical activity over the past week was assessed using the International Physical Activity Questionnaire (IPAQ) short-form<sup>11,12</sup>. Additionally, participants self-defined their running status at the time of registering for parkrun as regular, occasional, or none. Happiness was assessed with the 6-item Short Depression-Happiness Scale (SDHS)<sup>13</sup> which has shown good convergent validity with other measures of wellbeing<sup>13</sup>. Based on a comparison of scores on the Beck Depression Inventory<sup>14</sup>, a cut-off score of  $<10$  indicates possible cases of clinically relevant depression<sup>13</sup>. Stress was assessed by the 10-item Perceived Stress Scale<sup>15</sup>. Acceptable levels of internal and test-retest reliability have been demonstrated, and strong correlations with experiences of life events<sup>15,16</sup>.

The measures of weight, physical activity, happiness, and stress were repeated at the six and 12-month assessment points. Objective data on participant run performances during the study period were obtained from the *parkrun* database. Change in cardiorespiratory fitness was inferred from the difference between the first run time (baseline) and the fastest run recorded during the 12-month study, based on the strong correlation demonstrated between 5km running performance and maximum oxygen uptake<sup>17</sup>.

### **Data analysis**

Changes in continuous variables between baseline, 6 months, and 12 months, were analysed with repeated measures analysis of variance (ANOVA). Mixed ANOVAs were used to explore sub-group differences based on weight and running status, with bonferroni corrections. Standardised mean differences (Cohen's *d*) between baseline and 12 months were calculated as a measure of effect size.

Changes in categorical variables were examined using Chi-square tests ( $\chi^2$ ) and phi coefficients ( $\phi$ ). Associations between performance changes and other variables were examined through bivariate correlations, and multiple linear regression.

## RESULTS

### Participant characteristics

A total of 878 of adult registrants completed the baseline questionnaire. By 6 months, 553 were still attending *parkrun*, with 441 (79.7%) completing the questionnaire. At 12 months, 470 of the baseline sample still attended *parkrun*, and 354 (75.3%) completed the study. The retention of study participants was therefore 50.2% at 6 months, and 40.3% at 12 months. Participant characteristics and baseline scores on study outcome measures are provided in Table 1. No differences between study completers and non-completers were observed.

The majority of the sample were not regular runners at baseline, with 31.6% non-runners and 24.3% occasional runners or joggers. Nonetheless total physical activity levels were high with a mean of 350 minutes (5.8 hours) per week of total physical activity (moderate and vigorous intensity activity and walking across all domains), of which 138 minutes (2.3 hours) were of vigorous intensity. The number of participants reporting low total activity (<150 minutes per week) and low vigorous intensity activity (<75 minutes per week) levels were 47 (13.4%) and 100 (28.2%) respectively. Only 31 (8.8%) participants reported activity levels below both these minimum thresholds recommended for health maintenance<sup>18</sup>. Mean body mass index (BMI) was on the borderline of normal and overweight categories, with 30.5% classed as overweight ( $\geq 25$ ) and 8.5% as obese ( $\geq 30$ ).

### Outcome changes in the total sample

Table 2 summarises the change in physical activity, anthropometric, and psychological wellbeing outcomes between baseline and 12 months.

Significant changes over time were reported for both total physical activity ( $F_{(2, 556)} = 11.026$ ,  $p < 0.001$ ) and vigorous intensity activity ( $F_{(2, 564)} = 6.023$ ,  $p = 0.003$ ). Significant increases in total activity and vigorous activity were observed at 6 months (76.9 and 20.8 minutes respectively per week). By 12 months total physical activity had declined, but remained significantly higher than baseline (39.4 minutes per week). There was no sustained increase in vigorous intensity activity at 12 months with the reported volume returning to baseline levels. In the small sub-sample of participants ( $n = 31$ ) who reported low levels of both total activity (<150 minutes per week) and vigorous intensity activity (<75 minutes per week), there were larger and more sustained changes in physical activity. A mean increase

of 194.2 (95% confidence interval: 125.1, 263.3) minutes per week of total activity and 60.2 (95% confidence interval: 13.2, 107.2) minutes of vigorous activity were observed at 12 months.

Significant changes over time were observed for BMI ( $F_{(2, 556)} = 22.528$ ,  $p < 0.001$ ). Reductions in BMI were observed at 6 months ( $-0.5 \text{ kg/m}^2$ ) and partly maintained at 12 months ( $-0.3 \text{ kg/m}^2$ ). This equated to absolute weight change of  $-1.0 \pm 4.2 \text{ kg}$  at 12 months, and relative weight change of  $-1.1 \pm 5.3\%$  (weight change as a proportion of baseline weight). For participants of normal weight at baseline ( $n = 209$ ), there was little relative change ( $-0.2 \pm 4.1\%$ ). Overweight participants ( $n = 105$ ) recorded a difference of  $-1.9 \pm 6.3\%$ , and for those who were obese ( $n = 30$ ) the change was  $-4.1 \pm 6.6\%$ . A small significant correlation existed between weight change and the number of runs attended over 12 months ( $r = -0.20$ ,  $p < 0.001$ ).

For both happiness ( $F_{(2, 558)} = 11.074$ ,  $p < 0.001$ ), and perceived stress ( $F_{(2, 554)} = 16.345$ ,  $p < 0.001$ ), there were significant changes over time. Happiness scores increased significantly after 6 months and were maintained at 12 months representing a small positive effect size ( $d = 0.22$ ). The corresponding number of participants reaching the threshold (score  $< 10$ ) for possible depression was reduced from 39 (11.0%) at baseline to 28 (7.9%) by 12 months ( $\chi^2 = 54.1$ ;  $p < 0.001$ ;  $\phi = 0.40$ ). Similarly, there were significant reductions in perceived stress scores within 6 months, which were maintained at 12 months ( $d = -0.23$ ). Small significant correlations with total runs were observed for both happiness ( $r = 0.11$ ,  $p = 0.048$ ) and perceived stress ( $r = -0.13$ ,  $p = 0.014$ ) at 12 months.

### **Outcome changes in sub-groups**

Table 3 displays the changes in outcomes between baseline and 12 months for sample sub-groups based on initial weight category and runner status. Overweight/obese participants recorded a greater reduction in BMI ( $F_{(1, 342)} = 19.545$ ;  $p < 0.001$ ), and absolute weight ( $F_{(1, 342)} = 21.933$ ;  $p < 0.001$ ) than those of normal weight, but did not differ significantly on other outcomes. The effect size for BMI change among overweight/obese participants was  $d = -0.22$ , and the relative weight loss was 2.4%. The only significant difference based on initial runner status was a greater reduction in stress among novices than regular runners ( $F_{(1, 339)} = 4.502$ ;  $p = 0.035$ ), with an effect size of  $d = -0.32$  for novices.

### **Changes in run performance**

The mean reduction in 5km run time during the study was  $231.7 \pm 205.5$  seconds. The relative change in performance (difference between the first and fastest run time divided by the first run time) was  $-12.0 \pm 9.1\%$ . For non-runners ( $n = 110$ ), the absolute improvement was  $328.6 \pm 252.6$  seconds and relative improvement was  $15.8\% \pm 10.4\%$ .

Significant correlations were observed between change in run time and three variables: total runs ( $r = -0.42$ ;  $p < 0.001$ ), first run time ( $r = -0.63$ ;  $p < 0.001$ ), and weight change ( $r = 0.45$ ;  $p < 0.001$ ). No associations existed with change in total physical activity, change in vigorous physical activity, or age. The three variables associated with change in run time were entered into a multiple regression analysis, resulting in a significant model ( $F_{(3, 305)} = 146.0$ ,  $p < 0.001$ , adjusted  $R^2 = 0.585$ ), explaining 58.5% of the variance. All three variables were significant predictors of the fitness change: total runs ( $B = -5.132$ ,  $\beta = -0.299$ ,  $p < 0.001$ ), first run time ( $B = -0.294$ ,  $\beta = -0.528$ ,  $p < 0.001$ ), weight change ( $B = 11.500$ ,  $\beta = 0.299$ ,  $p < 0.001$ ).

## DISCUSSION

### Main findings of this study

This study provides the first prospective data indicating small but meaningful changes in physical activity, weight, and wellbeing outcomes during 12 months of participation in *parkrun*.

Self-reported physical activity levels were high at registration, including those self-classifying as non-runners. Nonetheless total activity levels and vigorous intensity physical activity both increased in the short-term. The subsequent decline observed after 6 months may reflect the well-established pattern of diminished activity over time that is consistently reported even among motivated individuals<sup>19</sup>. It is also possible that seasonal effects contributed to these changes, since participants would have reached the 6-month measurement point in the spring or summer, and the 12-month point in autumn or winter. Physical activity levels generally peak in the warmer months<sup>20</sup>, with this trend particularly strong in British adults for both outdoor and indoor activities<sup>21</sup>.

Although increases in physical activity differed little between novice and regular runners, there were notable changes among the small proportion of participants who started with low activity levels (i.e. below minimum guidelines). The sustained increase of over three hours of total physical activity and one hour of vigorous activity per week compares favourably with results of interventions specifically designed to promote physical activity<sup>22</sup>.

### What is already known

One advantage of *parkrun* over other mass participant events is the weekly occurrence of events. This may be significant in helping maintenance of physical activity for people without a background in exercise. This is supported by research with Dutch adults undertaking a 6-week 'Start to Run' programme<sup>23</sup>. At the end of the group-based programme, self-reported vigorous physical activity had increased by 210 minutes per week, and after six months it was still 144 minutes higher than baseline.



Sixty-nine percent of participants reported continuing to run independently or as part of club. The regular opportunity to run with group support offered by *parkrun* was identified as crucial for maintaining exercise in interviews with previously inactive participants<sup>24</sup>.

The changes in self-reported weight outcomes in this study are encouraging. Guidelines from NICE (National Institute of Health and Care Excellence) indicate that lifestyle weight management programmes for overweight and obesity typically lead to a 3% loss of initial body weight<sup>25</sup>. Hence the 2% mean loss for overweight participants, and 4% for those who were obese in this study, compare favourably with tailored interventions. It is important to note that there was no monitoring of diet or alcohol intake during the study, and alterations in these variables may explain the outcomes observed. Nonetheless, the strong evidence for regular physical activity leading to weight loss<sup>26</sup>, makes it plausible that participation in a regular running event contributed to these changes. The significant correlation between the degree of weight change and the attendance record, supports earlier findings of weight control being attributed to *parkrun* participation, particularly among the more regular attenders<sup>9</sup>.

Increases in happiness scores and reductions in perceived stress were recorded in this study, with the changes in the first 6 months maintained at 12 months. These findings support those from previous studies that have indicated wellbeing benefits associated with this event. In a cross-sectional study of 850 participants of *parkrun* in Australia, perceived mental health benefits of taking part and community connectedness were associated with overall wellbeing and satisfaction with life<sup>27</sup>. Similarly, mental wellbeing and community spirit were benefits of *parkrun* directly identified by more than three quarters of UK survey participants<sup>9</sup>. Qualitative analyses of interview data have confirmed the importance of the social interactions and support experienced through *parkrun* to the improvements in wellbeing received<sup>28,24</sup>. This highlights the added value of the community involvement inherent in *parkrun* events, ensuring that they offer more than a simple opportunity to run.

Finishing time data suggested fitness increases over the course of the study, and these were particularly marked among the initial non-runners. The regression analysis indicated that change in performance was associated with the first run time, with an improvement of 0.3 seconds per second taken during the first run. Weight loss was also a significant predictor, with an 11-second reduction in finishing time for each kilogram of weight lost during the study. Finally, attendance frequency was related to performance change, with a 5-second improvement for each additional run attended. These are unsurprising findings, since slower runners have more scope for improvement, and body composition and running frequency are established contributors to running faster<sup>29</sup>. Changes in fitness must be interpreted cautiously in this study, since they are inferred from run times, rather than a fitness

test. Nonetheless 5km performance is strongly correlated with maximal oxygen uptake<sup>17</sup> and lactate threshold<sup>30</sup>, and increased fitness was the most frequently reported advantage of taking part in parkrun in earlier research<sup>9</sup>. Cardiorespiratory fitness is associated with reduced risk of multiple health problems<sup>31</sup>, and lower mortality rates<sup>32</sup>. Running is known to be one of most effective ways of increasing cardiometabolic fitness<sup>33</sup>, and there are strong associations between faster running pace and lower cardiovascular risk factors<sup>34</sup>.

### **What this study adds**

Collectively these results add support to previous suggestions of potential public health value of *parkrun*<sup>7-9,35</sup>. Although average improvements in all outcomes were modest, this is expected in a sample of largely healthy, active adults who voluntarily engage in running. The prevalence of obesity was unsurprisingly lower than reported for general population samples (9% versus 26%), and the proportion meeting physical activity guidelines was higher (91% versus 58-66%)<sup>36</sup>.

Of greater note, are the larger gains observed for smaller sections of the sample who were inactive, overweight, or depressed at baseline, for whom parkrun may facilitate valuable health and wellbeing benefits. Based on the principle that significant public health benefit can be achieved through small changes among many people, or large improvements for fewer individuals<sup>37</sup>, *parkrun* appears to have considerable potential impact on population health.

The park context in which events take place, may be particularly important to consider. A wealth of research has indicated the health benefits of exposure to natural settings in general<sup>38</sup>, and parks in particular<sup>39</sup>. Proximity to parks or other green space is associated with physical activity levels in both the US<sup>40</sup> and UK<sup>41</sup>, and exercising in these environments ('green exercise') leads to greater physical and mental wellbeing than synthetic settings<sup>42,43</sup>. In earlier interviews with *parkrun* participants, the natural outdoor environments of events were identified as an attraction to attending<sup>28</sup>.

### **Study limitations**

Except for attendance and time data, all outcomes were based on self-reported measures, which can be influenced by recall and response biases. For example, the IPAQ has been shown to overestimate physical activity<sup>12</sup>. Self-reported weight is, however, highly correlated ( $r = 0.9$ ) with measured weight<sup>44</sup>.

Another important limitation is the uncontrolled study design. Since *parkrun* is an existing and regular community event, including a control arm is difficult. Therefore, this study cannot account for multiple factors outside of *parkrun* that may have contributed to the positive changes observed.

Retention of participants at 12 months was only 40%. Hence it is possible that people remaining involved were mainly those who perceived benefits of attending *parkrun*, leading to inflated positive outcomes in the study. Although there were no baseline differences between study completers and non-completers, reasons for ceasing study participation are not known. Notably, most of those discontinuing the study had stopped attending *parkrun*. The nature of a free-of-charge, community event in fixed weekly slot, inevitably involves variability in commitment and scheduling conflicts over time. Nonetheless, the adherence rate compares favourably with data on gym members where less than 4% maintained attendance for 12 months<sup>45</sup>. Previous qualitative research suggested that factors such as low cost and the outdoor environment enhanced the accessibility and appeal of parkrun over exercising in gyms<sup>28</sup>.

In conclusion, significant changes in weight, fitness, and wellbeing outcomes indicate the public health benefits of regular participation in *parkrun*. Future research of this subject will require objective measures of physical activity and body composition, along with monitoring of diet, and other lifestyle factors to provide more rigorous assessment against a suitable control group. Information on reasons for attrition would enhance understanding of the extent to which *parkrun* can contribute to population health.

## **FUNDING**

This research did not receive any funding.

## **ACKNOWLEDGMENTS**

The authors are grateful to Dr Chris Wright for time spent extracting data for study participants from the *parkrun* database.

## **CONFLICT OF INTEREST**

There was no involvement from *parkrun* in the study design and conduct, or data analysis and interpretation. At the time of data collection Mary Hickson was married to an employee of *parkrun*. Clare Stevinson and Mary Hickson were invited to become members of the *parkrun* research board while the study was ongoing.

## REFERENCES

1. Bauman A, Murphy N, Lane A. The role of community programmes and mass events in promoting physical activity to patients. *British Journal of Sports Medicine* 2009;43:44-6.
2. Murphy N, Lane A, Bauman A. Leveraging mass participation events for sustainable health legacy, *Leisure Studies* 2015;34:758-66.
3. Bowles HR, Rissel C, Bauman A. Mass community cycling events: Who participates and is their behaviour influenced by participation? *International Journal of Behavioral Nutrition and Physical Activity* 2006;3:39.
4. Funk D, Jordan J, Ridinger L, Kaplanidou K. Capacity of mass participant sport events for the development of activity commitment and future exercise intention. *Leisure Sciences* 2011;33:250-68.
5. Lane A, Murphy NM, Bauman A. The Impact of Participation in Flora Women's Mini Marathon on Physical Activity Behaviour in Women. Research Report 1. Ireland, Centre for Health Behaviour Research, Department of Health Sport and Exercise Sciences, Waterford Institute of Technology and Irish Sports Council, 2008 [online]. Available at: [http://www.sportireland.ie/Research/Women%27s\\_Mini\\_Marathon\\_Report\\_2009\\_/Women%27s\\_Mini\\_Marathon\\_2.pdf](http://www.sportireland.ie/Research/Women%27s_Mini_Marathon_Report_2009_/Women%27s_Mini_Marathon_2.pdf) (accessed 18.12.17).
6. parkrun [online]. Available at: <http://www.parkrun.org.uk/> (accessed 18.12.17).
7. Masters N. Parkrun eases the loneliness of the long-distance runner. *British Journal of General Practice* 2014;64:408.
8. McCartney M. Combination of exercise and social interaction is why I love parkrun *British Medical Journal* 2015;350:h230.
9. Stevinson C, Hickson M. Exploring the public health potential of a mass community participation event. *Journal of Public Health* 2014;36:268-74.
10. Office for National Statistics. 2011 Census for England and Wales. Available at: <http://www.ons.gov.uk/ons/guide-method/census/2011/index.html> (accessed 18.12.17).
11. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise* 2003;35:1381-95.
12. Lee PH, MacFarlane DJ, Lam TH, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* 2011;8:115.
13. Joseph S, Linley PA, Harwood J, Lewis CA, McCollam P. Rapid assessment of well-being: The Short Depression-Happiness Scale. *Psychology and Psychotherapy* 2004;77:463-78.

14. Beck AT, Rush AJ, Shaw BF, Emery G. Cognitive therapy of depression: A treatment manual. New York: Guilford, 1979.
15. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *Journal of Health and Social Behaviour* 1983;24:385-96.
16. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S (eds.) *Social Psychology of Health*. Newbury Park, CA: Sage, 1988.
17. Ramsbottom R, Nute MGL, Williams C. Determinants of five kilometre running performance in active men and women. *British Journal of Sports Medicine* 1987;21:9-13.
18. Chief Medical Officers of England, Scotland, Wales, and Northern Ireland. *Start Active, Stay Active - a report on physical activity for health from the four home countries' Chief Medical Officers*. London: Department of Health, 2011.
19. Marcus BH, Dubbert PM, Forsyth LH, McKenzie TL, Stone EJ, Dunn AL, Blair SN. Physical activity behavior change: issues in adoption and maintenance. *Health Psychology* 2000;19:32-41.
20. Tucker P, Gilliland J. The effect of season and weather on physical activity: A systematic review. *Public Health* 2007;121:909-22.
21. Uitenbroek DG. Seasonal variation in leisure time physical activity. *Medicine and Science in Sports and Exercise* 1993;25:755-60.
22. Lane A, Murphy N, Bauman A, Chey, T. Randomized controlled trial to increase physical activity among insufficiently active women following their participation in a mass event. *Health Education Journal*, 2010;69:287-96.
23. Ooms L, Veenhof C, de Bakker DH. Effectiveness of Start to Run, a 6-week training program for novice runners, on increasing health-enhancing physical activity: a controlled study. *BMC Public Health* 2013;13:697.
24. Wiltshire G, Stevinson C. Exploring the role of social capital in community-based physical activity: qualitative insights from *parkrun*. *Qualitative Research in Sport, Exercise and Health* 2018;10:47-62.
25. National Institute of Health and Care Excellence. *Weight management: lifestyle services for overweight or obese adults [PH53]*. London, UK: NICE, 2014.
26. Thorogood A, Mottillo S, Shimony A, Filion KB, Joseph L, Genest J, et al. Isolated aerobic exercise and weight loss: a systematic review and meta-analysis of randomized controlled trials. *The American Journal of Medicine* 2011;124:747-55.
27. Grunseit A, Richards J, Merom D. Running on a high: parkrun and personal well-being. *BMC Public Health*. 2017;18:59.
28. Stevinson C, Wiltshire G, Hickson M. Facilitating participation in health-enhancing physical activity: a qualitative study of parkrun. *International Journal of Behavioural Medicine* 2015;22:170-7.

29. Bale P, Bradbury D, Colley E. Anthropometric and training variables related to 10km running performance. *British Journal of Sports Medicine* 1986;20:170-3.
30. Kumagai S, Tanaka K, Matsuura Y, Matsuzaka A, Hirakoba K, Asano K. Relationships of the anaerobic threshold with the 5km, 10km, and 10-mile races. *European Journal of Applied Physiology* 1982;49:13-23.
31. Williams PT. Vigorous exercise, fitness and incident hypertension, high cholesterol, and diabetes. *Medicine and Science in Sports and Exercise* 2008;40:998-1006.
32. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, Sugawara A, Totsuka K, Shimano H, Ohashi Y, Yamada N, Sone H. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *Journal of the American Medical Association*, 2009;301:2024-35.
33. Oja P, Titze S, Kokko S, Kujala UM, Heinonen A, Kelly P, Koski P, Foster C. Health benefits of different sport disciplines for adults: systematic review of observational and intervention studies with meta-analysis. *British Journal of Sports Medicine* 2015 49:434-40.
34. Williams PT. Relationships of heart disease risk factors to exercise quantity and intensity. *Archives of Internal Medicine* 1999;158:237-45.
35. Wiltshire G, Fullagar S, Stevinson C. Exploring *parkrun* as a social context for collective health practices: running with and against the moral imperatives of health responsabilisation. *Sociology of Health Illness* 2018;40:3-17.
36. National Statistics. Statistics on obesity, physical activity and diet: England 2018. Health and Social Care information Centre, 2018
37. Frieden TR. Six components necessary for effective public health program implementation. *American Journal of Public Health* 2014;104:17-22.
38. Bowler DE, Buyung-Ali LM, Knight TM, Pullin AS. A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health* 2010;10:456.
39. Lee ACK, Maheswaran R. The health benefits of urban green spaces: a review of the evidence. *Journal of Public Health* 2011;33:212-22.
40. Han B, Cohen D, McKenzie TL. Quantifying the contribution of neighborhood parks to physical activity. *Preventive Medicine* 2013;57:483-7.
41. Mytton OT, Townsend N, Rutter H, Foster C. Green space and physical activity: an observational study using Health Survey for England data. *Health Place* 2012;18:1034-41.
42. Thompson-Coon J, Boddy K, Stein K et al. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science and Technology* 2011;45:1761-72.

43. Gladwell VF, Brown DK, Wood C, Sandercock GR, Barton JL. The great outdoors: how a green exercise environment can benefit all. *Extreme Physiology and Medicine*. 2013;2:3.
44. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *Journal of the American Diet Association* 2001;101:28-34.
45. Sperandei S, Vieira MC, Reis AC. Adherence to physical activity in an unsupervised setting: Explanatory variables for high attrition rates among fitness center members. *Journal of Science and Medicine in Sport* 2016;19:916-20.



Table 1. Characteristics and baseline scores of all participants and those completing and not completing the 12-month study

Baseline characteristics	Total sample (n = 878)	Study completers (n = 354)	Study non-completers (n = 524)
Age (years)	41.8 ± 10.8	41.4 ± 10.9	42.0 ± 10.8
Female sex (%)	59.1%	55.9%	61.3%
Completed higher education (%)	72.7%	76.3%	70.2%
Employed full/part time (%)	85.8%	85.9%	85.7%
White ethnic group (%)	94.8%	95.5%	94.3%
Limiting disability (%)	4.4%	4.8%	4.2%
Good/very good health status (%)	83.9%	84.2%	83.8%
Overweight (%)	40.3%	39.0%	41.2%
Body mass index (kg/m <sup>2</sup> )	24.9 ± 3.8	24.9 ± 3.8	24.9 ± 3.8
Regular runner/jogger (%)	44.2%	44.1%	44.4%
Total physical activity (min/w)	373.8 ± 287.0	349.5 ± 265.7	390.3 ± 299.8
Vigorous physical activity (min/w)	142.9 ± 117.5	138.0 ± 118.2	146.3 ± 117.1
First parkrun time (s)	1840.4 ± 366.0	1836.4 ± 359.3	1843.4 ± 371.1
Happiness-depression (0-18)	13.7 ± 3.3	13.8 ± 3.2	13.6 ± 3.4
Stress (0-40)	16.1 ± 7.4	15.5 ± 6.8	16.4 ± 7.8

Notes: values are mean ± standard deviation unless stated otherwise

Table 2. Changes in physical activity, weight, and wellbeing outcomes after six and 12 months of *parkrun* participation among study completers (n = 354)

Outcome	Baseline mean $\pm$ SD	6 months mean $\pm$ SD	12 months mean $\pm$ SD	Mean change (95% CI) after 12 months	<i>p</i>	<i>d</i>
Total PA (min/w)	349.5 $\pm$ 265.7	426.4 $\pm$ 340.9	390.3 $\pm$ 278.2	39.4 (11.3, 67.5)	0.006	0.15
Vigorous PA (min/w)	138.0 $\pm$ 118.2	158.8 $\pm$ 126.4	136.8 $\pm$ 115.5	-1.4 (-14.6, 11.8)	0.831	-0.01
BMI (kg/m <sup>2</sup> )	24.9 $\pm$ 3.8	24.4 $\pm$ 3.6	24.6 $\pm$ 3.6	-0.3 (-0.2, -0.5)	<0.001	-0.07
Weight (kg)	73.5 $\pm$ 14.0	71.9 $\pm$ 13.3	72.5 $\pm$ 13.4	-1.0 (-0.5, -1.4)	<0.001	-0.08
Happiness (0-18)	13.8 $\pm$ 3.2	14.5 $\pm$ 2.8	14.5 $\pm$ 3.2	0.7 (0.4, 1.0)	<0.001	0.22
Stress (0-40)	15.5 $\pm$ 6.8	13.3 $\pm$ 6.9	13.9 $\pm$ 7.3	-1.6 (-1.0, -2.3)	<0.001	-0.21

Notes: SD: standard deviation; CI: confidence interval; *d*: Cohen's *d* effect size; BMI: body mass index; PA: physical activity

Table 3. Changes in physical activity, weight, and well-being outcomes between registration and 12 months of *parkrun* participation in sample sub-groups based on initial runner status and weight status.

Outcome	Initial runner status		Initial weight status	
	Novice (n = 198)	Regular (n = 156)	Normal (n = 214)	Overweight (n = 138)
Total PA (min/w)	46.0 (9.6, 82.5)	30.9 (-13.4, 75.3)	42.2 (7.9, 76.4)	35.5 (-14.0, 85.0)
Vigorous PA (min/w)	9.7 (-9.2, 28.6)	-15.5 (-33.5, 2.4)	1.8 (-14.0, 17.6)	-6.3 (-29.8, 17.2)
BMI (kg/m <sup>2</sup> )	-0.3 (-0.1, -0.5)	-0.4 (-0.1, -0.6)	-0.1 (0.1, -0.2)	-0.7 (-0.4, -1.0)*
Weight (kg)	-0.9 (-0.3, -1.5)	-1.1 (-0.4, -1.8)	-0.2 (0.2, -0.5)	-2.3 (-1.3, -3.2)*
Happiness	0.9 (0.5, 1.3)	0.4 (0.0, 0.8)	0.5 (0.2, 0.9)	0.9 (0.4, 1.3)
Stress	-2.3 (-1.4, -3.2)	-0.8 (0.1, -1.8)†	-1.9 (-1.1, -2.8)	-1.2 (-0.9, -2.3)

Notes: Data are mean change (95% confidence intervals). BMI: body mass index; PA: physical activity;

\*p < 0.001; †p < 0.05